A.D. 1861, 9th DECEMBER. N° 3078.

Electric Telegraphs.

LETTERS PATENT to Cromwell Fleetwood Varley, of No. 4, Fortess Terrace, Kentish Town, in the County of Middlesex, Electrician, for the Invention of "IMPROVEMENTS IN ELECTRIC TELEGRAPHS."

Sealed the 29th April 1862, and dated the 9th December 1861.

COMPLETE SPECIFICATION filed by the said Cromwell Fleetwood Varley at the Office of the Commissioners of Patents, with his Petition and Declaration, on the 9th December 1861, pursuant to the 9th Section of the Patent Law Amendment Act, 1852.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, CROMWELL FLEETWOOD VARLEY, of No. 4, Fortess Terrace, Kentish Town, in the County of Middlesex, Electrician, send greeting.

WHEREAS I am in possession of an Invention for "IMPROVEMENTS IN ELECTRIC TELEGRAPHS," and have petitioned Her Majesty to grant unto me, my executors, administrators, and assigns, Her Royal Letters Patent for the same, and have made solemn declaration that I am the true and first Inventor thereof.

NOW KNOW YE that I, the said Cromwell Fleetwood Varley, do hereby declare that the following Complete Specification, under my hand and seal, fully describes and ascertains the nature of the said Invention, and in what manner the same is to be performed, in and by the following statement, reference being had to the accompanying Drawings (that is to say) :—

Firstly, improvements in the source of electricity or batteries to lessen cost and obtain greater constancy of action.

Secondly, in the insulators to reduce the escape of electricity.

Thirdly, in the conductors to carry off the lightning discharges.

Fourthly, in the apparatus for discovering the locality of leaks (or escapes of electric fluid.

The battery is an improvement on my "gravity battery," patented on the Fifth day of December, One thousand eight hundred and fifty-four, No. 2,555, and consists in retarding the solution of the negative salt when the battery is not in action. A tube of metal or other conducting material reaching from above the fluid in the battery to the bottom of the cell (or nearly so, is connected electrically with a flat conducting tray or plate; the lower part of the tube is perforated to allow the solution of negative salt to cover the plate or tray at the bottom of the cell in a thin stratum on the principle of the "bird fountain." The positive metal is placed above the tray as far as possible from the tube as the cell will permit. The tube is from time to time filled with negative salt, and the whole cell filled with positive solution, generally dilute sulphuric acid or sulphate of zinc. The negative element, consisting of the tray and the tube, presents a large surface, and thus reduces the resistance of the battery. When the battery has not hard work to perform the tray is made deeper or several trays are placed one inside the other, or a compound tray is formed, so that as soon as the inner one is filled with saturated solution it overflows and fills the next. In other cases the solution is still further retarded by covering the negative plate or tray with sand, or, what is better, finely pulverized flint or glass cutters' mud, or a sheet of felt is placed over the plate or tray. To prevent the metal from depositing itself around the opening in the metallic tube and closing, it is often advisable to perforate the lower plate, which is elevated about a quarter of an inch above the bottom of the cell, and the tube is made to communicate with the space below the plate or tray; this is only necessary for batteries having hard work to perform. In some cases plaster of Paris is used to partly fill the space above the bottom of the tray, using a second and perforated metallic plate to form a space for the solution. I sometimes, when using the ordinary Daniells' battery with porous cells that have not hard work to perform, place a copper tube inside the porous cell for the negative element, with an opening or openings at or near the lower end, and fill the tube with crystals. This confines the solution chiefly to the lower portion of the porous cell, and thus reduces the consumption of sulphate of copper by local action, and materially retards the passage of the negative salt to the positive solution through the pores of the inner vessel.

Sometimes I still further reduce it by rendering the lower portion of the cell for an inch or so non-porous by glazing or by dipping the porous cell into melted tallow or other suitable substance. The batteries are particularly adapted for short circuits for railway telegraphs which are only occasionally worked, and not only economise sulphate of copper, but remain in action for a very long period without needing cleaning, recharging, or other attention. In extreme cases a copper tube with one end stopped with plaster or other suitable material is used, (the end of the tube being surrounded with plaster or plunged into a shallow porous vessel containing plaster in a soft state. The plaster is mixed with a solution of copper instead of water, or pulverized sulphate of copper is added to the the plaster. Glass tubes have been used in a somewhat similar manner as far as the tube is concerned.

My improvement consists in using a conducting tube with or without a plate or tray, by which a larger surface is exposed to action, and any negative salt outside the tube is not entirely lost, but still comes into action. Telegraphic insulators are generally made either of porcelain, glass, earthenware, or vulcanized caoutchouc.

My improvement consists in reducing their diameter as much as possible, and so constructing them of two or more insulating portions, so that if one fail to insulate the other part arrests the escaping electricity.

Secondly, in placing the wire as low down the side of the insulator as possible to reduce the leverage on the pin, whereby a pin of smaller diameter is used and greater insulation obtained.

Thirdly, when I use earthen or porcelain caps, I make them of the forms shewn in Figures 1 to 7. The part into which the pin goes is made as thin as is consistent with strength, as thin ware, being sounder and less liable to flaws, insulates better than thick.

Fourthly, the upper part of the insulator, that is to say, that portion above the ring into which the wire is bound, as also the hole into which the pin goes, is left unglazed to enable the ware itself to be tested electrically before the pin is inserted.

Fifthly, the inside of the mouth of the insulator is rounded.

Figures 1, 2, and 3, the outside is sharp; this prevents in a great measure the drops of rain, when blown inside, from breaking into spray and moistening the surface all over.

Sixthly, I place the cap either upon a stone ware, earthen, or glass pin, of the form shewn in Figure 3.

Seventhly, or on an iron pin covered with vulcanized caoutchouc, Figure 2, *c.*

Eighthly, or on another insulating cap, Figure 1, *b.*

Ninthly, or two caps are used on a pin coated with vulcanized caoutchouc or Wrays' material.

Tenth, or a cap of vulcanized caoutchouc is used on the pin, Figure 9, or the pin *c*, Figure 2. The pin, Figure 9, is entirely covered with vulcanized caoutchouc, &c.

Eleventh, I sometimes make the caps out of a compound of rosin (or other suitable resin) and some powder such as "glass cutters' mud," powdered silica, &c.; sometimes a little gutta percha is added to take away brittleness. The caps, when damaged, can be remelted and reworked.

Twelfth, I sometimes varnish the earthen or porcelain caps with a non-conducting varnish and so improve the insulation.

The metal and inner pin, Figure 9, is generally made of steel, and this is sometimes tempered to give great strength and small diameter. The pins in Figures 1 and 2 are termed "bell pins," and are made to suit both the existing iron and wooden arms. On the sides of the earthenware or porcelain caps projecting pieces are sometimes formed, as shewn in Figures 4, 5, 6, and 7. Those marked *i* are to prevent the wire from falling; if the binding wire break, the upper ones *j* are to prevent the wire from lifting; *j* is generally made like a hook for greater security; *j* is sometimes placed so low that the wire has to be bent to be got into place, when "binding wire" can be dispensed with. When glass is used, I prefer window glass to the green bottle or white glass hitherto employed; the surface of the former resists the deposition of moisture from damp atmospheres, and so insulates better. Where the wires pass through tunnels or smokey places, or where very high insulation is required, I sometimes coat pieces of wire for a yard or so with vulcanized caoutchouc (or ebonite). These pieces of wire are inserted into the long wire after it is erected at each pole or support, and after it has been joined in, the other wire is cut out, and thus the electricity must escape over a long length of ebonite of small diameter before it can reach the support or insulator to escape to the ground. This insulation is very high indeed; gutta percha has been used in this way. All I claim is the use of ebonite or vulcanite for this purpose, being a more durable and perfect material.

The centre portion is sometimes made thicker when it is intended to attach the wire to the support without the intervention of any other insulator. With improved insulation more care is necessary to carry off lightning discharges. My vacuum conductor hitherto used is too expensive; my present one consists of a glass bulb, into which several platina wires are fused, one or more being connected with the earth, the other or others with the lines to be protected; one spare wire is left for testing the vacuum to see that air does not enter.

This is done by passing a small discharge of static electricity through the globe and observing the form of the spark. In addition, a helix containing an iron rod or rods is sometimes placed in circuit between the lightning conductor and the apparatus, &c. requiring protection. The iron requires time to magnetize, and thus by offering momentary resistance arrests all very sudden currents which are thus made to flow through the lightening conductor in which there is no magnetic inertia to be overcome. These helices with iron cores I term magnetic lightening conductors. The apparatus for discovering the locality of faults is an improvement on that patented by Cornelius John Varley and myself in June Twenty-third, One thousand eight hundred and fifty-nine, No. 1509, vide Figure 1.

The improvement now made consists of making the machine indicate the locality of the fault without any algebraical or numerical calculation by the operator. It consists of a differential galvanometer switch and key, which I prefer fixing on one board or tablet. It is not absolutely necessary to use a differential galvanometer; a Wheatstone's bridge may be used, but its want of delicacy makes the differential galvanometer best in practice. The key is for making or breaking battery contact. The switch, which has two positions, (labelled "numerator" and "denominator," connects the battery, &c., first, as shewn in the skeleton, Figure 11; secondly, as in Figure 12.

Modus operandi:—Suppose a leak to exist in a wire between station A and station B, and that A requires the distance of the fault or leak, A tells B to connect the defective wire to a good wire (of similar dimensions to the defective one); A then connects the good wire to the terminal marked "good line," Figure 10, the defective wire to the terminal marked "bad line," and the battery poles to C and Z. The switch is put in the first position marked "numerator," Figure 10, and the resistance necessary to bring the galvanometer to zero noted this sum (r) is set down for a numerator. The switch is then put into the second position marked "denominator," and the resistance necessary to bring the galvanometer to zero again noted. This amount (2 S) is set down as a denominator $\left(\frac{r}{2\,S}\right)$. The line from A to B being taken as unity, the fraction thus obtained indicates the distance of the fault from B. The above fraction indicates at what portion of the circuit, starting from B, the fault is located. Thus, suppose the fraction given by the machine to be $\frac{30}{40} = \frac{3}{4}$, the fault will be distant from B $\frac{3}{4}$ of the length of the circuit from A to B, and if the distance between A and B be sixteen miles in length, the leak will be $\frac{3}{4} \times 16$, twelve miles from B or four miles from A.

In this apparatus any set of units of resistance can be used, as proportion only is required.

Theory of the above.

Resistance of each wire between A and B $= x + y = s$.

Distance of fault from A $= x$.

" " B $= y$.

In the first test the resistance r is necessary to make $x = s + y$ } = (numerator) $= r$

In the second test the resistance of the two wires between A and B is obtained } = (denominator) $= 2\,S$.

$$x + r = s + y = x + 2\,y,$$

$$r = 2\,y \text{ and}$$

$$\frac{r}{2S} = \frac{y}{2S} = \frac{y}{S} = \frac{\text{“ numerator ”}}{\text{“ denominator ”}}.$$

The resistance coils are made to shew at a glance the resistance in circuit; they are made in two or more sets, the first shewing 1 to 10 units, the second from 10 to 100, and so on. The first set I prefer making of four coils of 1, 2, 3, and 4 units resistance, and which by combination will give from 1 to 10 units; the second set is ten times as large, or 10, 20, 30, and 40 units, and so on. The coils are connected in one long series or circuit, but each coil has a short circuit spring (or tumbler), and over each set of tumblers or springs passes an axle with cams. These cams, by depressing the right number of tumblers, put into circuit coils, giving the amount of resistance desired. On the axle there is a divided plate t, Figure 13, which indicates the number of units of resistance in circuit.

The first axle gives from	- -	0 to 9
" second " "	- -	10 to 90
" third " "	- -	100 to 900

and so on, if necessary (the same coils can be made to give 1100 units when all are in circuit). Thus then at a glance is seen what amount of resistance is in circuit. Suppose the resistance in circuit be 768 units, the instrument will shew 7, 6, 8, and the following coils will be in circuit:—

First (or right-handle axle)	$4 + 3 + 1$	$= 8$
Second (or middle) axle	$40 + 20$	$= 60$
Third (or left-hand) axle	$400 + 300$	$= 700$
		768 units.

To enable the galvanometer to be turned about, it carries on an insulated axis four metallic rings, which are connected with the four ends of the coil wires; springs press against these rings, and thus connect the coils with the base of the case. Thomson's shunts are attached to each coil to make the galvanometer multiply or divide to any describable extent. The apparatus so

constructed brings "distance testing" within the reach of unscientific minds, enormously expedites the operation, and reduces the chances of error.

In some cases I compensate the resistance coils for variation of temperature by forming them partly of coils of wire, partly of tubes of water, (or solution of any suitable salt or acid,) the former increase and the latter decrease in resistance by elevation of temperature. When testing the insulating power of a submarine or subterranean line, I prefer using the static test, and noting how long a period of time the charge in the wire is falling from any one tension to any other. This test is sometimes difficult, owing to the slowness of the motion of the instruments used in indicating or coming to rest, and I have constructed a defferential apparatus for testing this, as shewn in skeleton by Figures 15, 16, 17. The moment the wire under test falls to the required tension the needle goes over from w^3 to w^2; when the wire is charged the tension in w^3 and w^4 is lower than that in w^1 and w^2, and the needle is repelled by w^1 and w^2. As soon as the tension of the charge in the wire becomes less than w^3 and w^4, the needle passes over, as before described.

The galvanometer and resistance coils and static testing apparatus are only shewn in skeleton, as the other parts of the apparatus may have any form the maker likes, and are well understood by all people interested in these matters. The apparatus cannot be used on a vibrating counter, but by the following support or table the tremors are cut off. A heavy mass or slab has 3 or 4 feet or supports made of elastic material; the sensitive instruments are supported on these; the tremors are lost in the elastic supports of the heavy slabs. Telegraphic relays mounted on such supports work much better, and with weaker currents than when placed on ordinary tables.

Description of Drawings.

Figures 1, 2, 3, and 8 are sections; Figures 4, 5, 9, 14, 16, and 17 are elevations; Figures 6, 7, 13, and 15, are bird's eye views; Figures 10, 11, and 12 are skeleton Diagrams to shew connections, as are also Figures 15, 16, and 17. The letters correspond in all the Figures. Figure 1, an insulator composed of two caps *a* and *b*, generally earthenware, connected together, and then cemented on the iron pin *c*; this pin is bolted into the iron or wooden arm fixed on a telegraph pole, vide Figure 2, *d*. Figure 2 shews a single cap (*a*) mounted on an iron pin *c*, which is coated with ebonite *e* (vulcanised caoutchouc) or "Wray's material." Figure 3 shews a cap mounted on an earthenware, glass, or porcelain pin (*f*); this pin is formed with a flat surface at *d* and *g*, and is bolted to the side of the arm by the bolt *g*. An iron collar or washer *h* is placed under the head of *g* to give strength to the

earthen pin. Figures 4, 5, 6, and 7 represent caps similar to those in Figures 1, 2, and 3, with projections formed on them to prevent the wire from falling, and in some cases to dispense with the binding in wire altogether. Figures 4 and 5 are front and side views, and Figure 6 a bird's eye view; *i* is the lower projecting piece, and in some cases caps are made with only this one projection to catch the line wire if the binding break; but I prefer having the projection *j*, which is formed like a hook (Figure 5), so that if the binding wire break the line wire cannot jump out of the hook *i*. In Figures 1, 2, 3, 4, and 5, the space *k* is to receive the binding in and also the main wire, as is well understood; (*i* and *j*, Figure 4) are placed as near together as possible, space enough only being left to get the wire over one and under the other into its place. By tilting the insulator *i* and *j* are placed so that while tightening up the net in Figure 2 the twisting of the insulator clamps the wire tightly into the hooks, and leaves them in the best position for preventing the wire from escaping. Figure 7 shews a cap with three lower hooks *i*, and three upper ones *j*, the object being, that if one of these hooks break off by twisting the insulator round, fresh hooks present themselves; these hooks *i* are sometimes made so that the wire cannot be put in unless it be bent, and in this way the wire is clamped tightly by the hooks, and no binding in is necessary. In this case the upper hooks can be dispensed with, or the pieces are so arranged that the wire has to be bent downwards at *j* and upwards at *i*, to allow of its being put into its place; by these means the wire is clamped firmly in, and no binding is required. Figure 8 represents a cap made of vulcanised caoutchouc, known as ebonite; these are frequently used in place of *a* or *b*, the insulating power of the material being very high, but from its nature it is necessary to protect it from the action of the direct rays of the sun; I therefore prefer using it inside an earthenware cap, as in Figure 1. Figure 9 represents a steel pin entirely covered with this material (vulcanised caoutchouc), on the lower portion of which a screw is sometimes cut, or a course file passed over it obliquely to form a thread which is sufficient to make it screw tightly into the wooden arms generally used on telegraph poles. The object of covering the pin entirely is to prevent any electricity that might escape through any imperfection at the top of the pin to the interior metal getting out again; thus in the covered pin there are two chances against failure of insulation, as also is the case in Figure 1, where there are two stoneware or other caps, and in Figure 2, where a stoneware cap is placed on a pin previously covered with the insulating material described. In Figure 3 the insulating cap is placed upon an insulating pin (*f*) of glass, porcelain, or stoneware, so that if one

portion of the insulator be defective, the other portion shall arrest the escaping electricity. Between the pin *f* and the arm *d*, and between the iron washer *h* and the pin are placed felt washers *o*, *o*, *o*, *o*, to prevent the bolt from crushing the brittle material. The pin "*c*," Figures 1 and 2, is made conical at "*n*," so that it shall fit into any of the existing iron arms, and being conical, their difference of size does not prevent these insulators from making a good fit; the screw is made so long that it also fits into the wooden arms. Figure 10 is a skeleton Diagram of the differential galvanometer for indicating the locality of faults, without numerical or algebraical calculation on the part of the operator. The defective wire to be tested is connected to the terminal marked "bad line;" the good wire (which has to be joined to the defective wire at station B) is connected to the terminal marked "good line." The switch, when in the position shewn in Diagram (marked "numerator"), connects the wires and apparatus, as shewn in Figure 11, and when in the position shewn by the dotted lines (marked "denominator") the wires are connected, as in Figure 12. On depressing the key the current from the battery circulates in opposite directions through the two halves of the differential galvanometer, and whenever the resistances in the two circuits are alike, the currents flowing through the galvanometer being equal, neutralise each other, and the needle stands at zero. The Diagrams explain themselves. Figures 13 and 14 represent the arrangement for putting the various resistance coils in and out of circuit "*p*," the axles carrying the cam wheels "*q*," which depress when required the springs "*v*," as shewn in Figure 14 at *s*, where the circuit being broken the coil of 10 units is thrown into circuit. These cams are so cut that when the disc "*t*" has nought (0) uppermost no springs are depressed, and consequently none of the resistance coils are in circuit. When the wheel "*t*" is turned one division and the number 1 is up, the spring r 1 is depressed, and the coil of one unit is in circuit; when the wheel is turned a second division v^1 is released and r^2 depressed; when turned a third division r^3 is the only spring depressed; and when turned a fourth division r^4 is depressed; and when turned a fifth division the springs r^1 and r^4 are depressed, putting in circuit five units, and so on to 9 units. Thus the barrel "*p*" goes from 0 to 9 units, and the barrel p^1 by a similar arrangement goes from 0 to 99 units, and so on with the third or fourth barrel if required; the cams "9" are made either of ebonite to insulate them from the axle *p*, or if made of metal, they are insulated by the interposition of any convenient non-conducting substance, or the lumps "*u*" or the springs *r*, Figure 14, are made of insulating material. Figures 15, 16, and 17 represent the differential apparatus for testing wires by static electricity; "*v*" is a wire of any

non-magnetic metal, mounted by a metal cap on a point similar to a compass needle, or to that used in the "Peltier electrometer; "w^1," "w^2," and "w^3," and w^4 are pieces of metal in which the wire "v" can move. They are connected as shewn in the Diagram; "w^1" and "w^2" are connected to the line to be tested; "w^3" and "w^4" are connected with a portion only, say, one half of the battery used for testing the wire, and one of the poles of which battery is connected with the earth. The other pole of the whole of the battery is connected with the needle "v," and also to the four wires "x." To test the wire connection is formed at "y" between the whole of the battery power and the line to be tested; "w^1" and "w^2" are then charged to the same extent as the needle "v," which is driven over into "w^3" and "w^4," which are only charged by a portion of the battery. The contact at "y" is then broken, and as the electricity in the wire slowly escapes, and the tension in it and in "w^2" decreases to less than that of "w^3" and "w^4," the wire v is repelled from "W^3" to "W^2." The time elapsed between the break of contact at y and the repulsion of the wire "v" from w^3 to w^2 is the measure of the insulating power of the material covering the wire. For the same material free from mechanical or other accidental defects this time is the same, no matter what the length of wire under test may be, nor what the thickness of the insulating covering. For as the insulation is increased by thickness of material on the wire, so in exactly the same proportion is the charge by induction decreased, hence the time is always the same. The 4 wires "x" are to prevent the wire v when driven to either side from making contact with the pieces w, v, and x, being charged alike, mutually repel each other, and v is ready to move with the least force, and all liability to stick from fixed stops prevented. The rest of the apparatus being readily understood, and variable according to the maker's fancy is omitted for greater clearness.

I claim the use of a tube of metal (with or without a tray or trays, or plate, at or near its lower end), for the negative element of a Daniell's battery without porous cell as described.

The use of finely pulverised flint or glass cutters' mud, or felt, or plaster of Paris in conjunction with the tubular negative element to still further retard the solution of the negative salt.

The use of a metallic tube for the negative element, the end of which is closed with plaster of Paris, or plunged into a porous vessel.

The use of plaster of Paris mixed with sulphate of copper for the above purposes.

The use of copper tubes, with a hole or holes near the lower end only, (instead of copper plates,) placed inside the porous cells of ordinary Daniell's

battery for the purpose described. Also making the lower portion of the porous cell non-porous for the purpose described.

The form of the caps, Figures 1, 2, 3, and 8.

The "trumpet" form of the lip of the insulator to prevent drops of water from breaking into spray inside the insulator.

The form of the bell pins "C."

The use of an earthenware, porcelain, china, or glass cup inside an earthenware or china, or porcelain or glass cup, Figure 1.

The use of ebonite in conjunction with stoneware or porcelain for telegraph insulators.

The use of an earthenware pin, as in Figure 3, for the purpose described.

The use of the projecting ears in earthenware or porcelain insulator caps, as shewn in Figures 4, 5, 6, and 7, for the purposes explained.

The varnishing or covering earthenware, glass, or porcelain insulators while hot with varnish or any other material to increase the insulating power of the surface.

The pin (Figure 9) covered entirely with insulating material.

The insular caps of a fusible resinous compound as described.

The insertion into aerial circuits at the points of support of lengths of wire partly covered with vulcanite as described.

The apparatus for indicating the locality of defects in telegraphic lines without algebraical or numerical calculation.

The arrangement shewn in Figures 13 and 14, for combining the coils of different resistances, and shewing at a glance what resistance is in circuit.

The differential static testing arrangement shewn in Figures 15, 16, and 17.

The use of a heavy mass mounted on elastic feet for insulating delicate electrical instruments from tremors.

The use of the improved vacuum conductors as described, and also of the magnetic lightning conductor, consisting of a metallic helix containing a bar of soft iron.

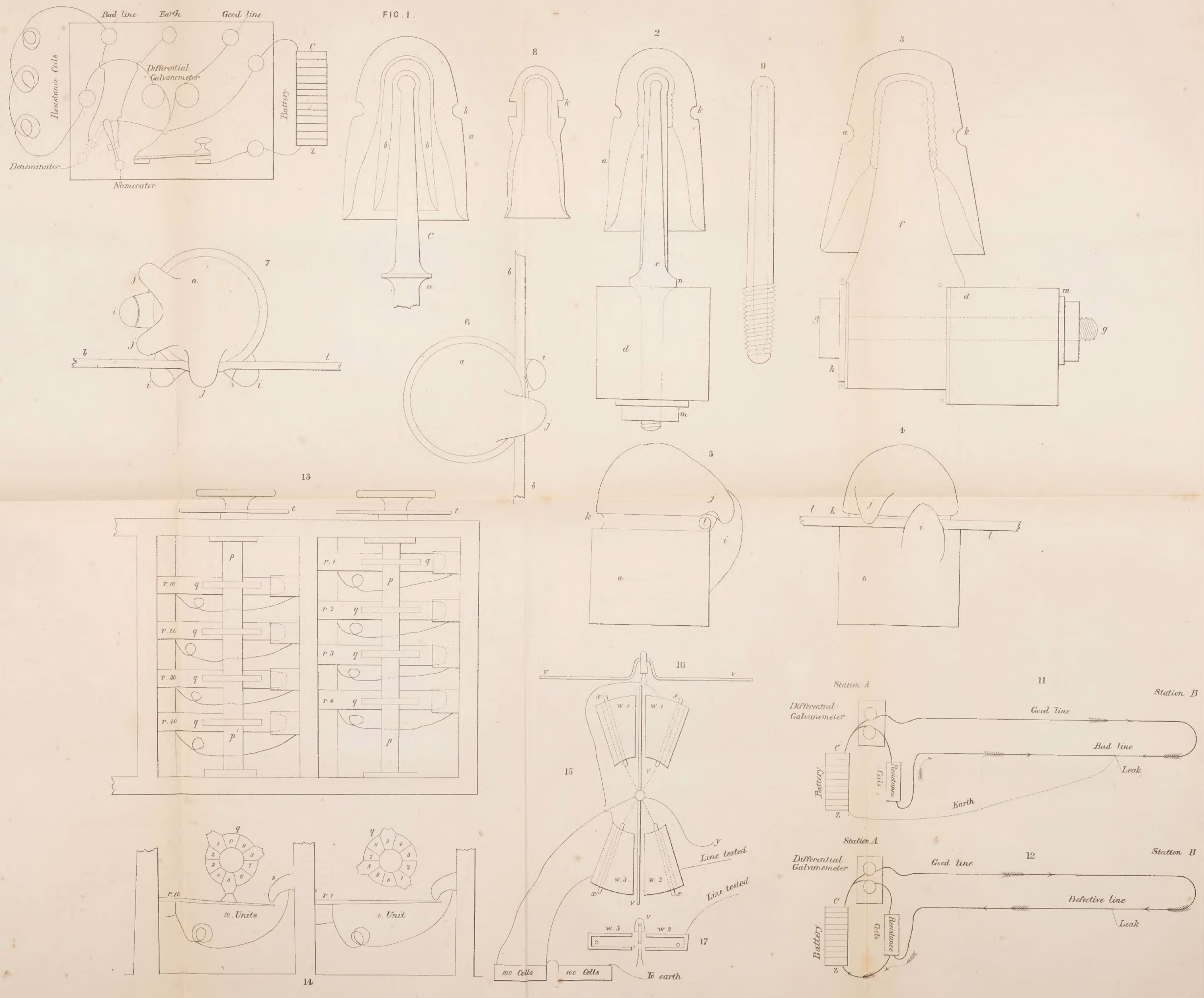
In witness whereof, I, the said Cromwell Fleetwood Varley, have hereunto set my hand and seal, the Seventh day of December, in the year of our Lord One thousand eight hunded and sixty-one.

C. F. VARLEY. (L.S.)

LONDON:
Printed by George Edward Eyre and William Spottiswoode,
Printers to the Queen's most Excellent Majesty. 1862.

A.D. 1861, DEC. 9, Nº 3078.
VARLEY'S COMPLETE SPECIFICATION.

(1 SHEET.)



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Drawn on Stone by Malby & Sons.

LONDON: Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE,
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